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ABSTRACT

This paper applies cost-effectiveness analytic techniques to decisions on teacher recruitment and retention. The data are derived from the U.S. Office of Education's Survey of Equal Opportunity for the school year 1965-66. Evidence relating teacher characteristics to student achievement is combined with data on the costs of obtaining teachers with different characteristics. This evaluation suggests that recruiting and retaining teachers with higher verbal scores is five to ten times as effective per dollar of teacher expenditure in raising achievement scores of students as the strategy of obtaining teachers with more experience. Separate estimates are made for black and for white 6th graders in schools of the metropolitan North. (Author)

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Research and Development Memorandum No. 41

COST-EFFECTIVENESS ANALYSIS AND EDUCATIONAL POLICY -- PROFUSION, CONFUSION, PROMISE

Henry M. Levin

School of Education
Stanford University
Stanford, California

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Abstract

The purpose of this paper is that of applying cost-effectiveness analytic techniques to decisions on teacher recruitment and retention. The data are derived from the U.S. Office of Education's Survey of Equal Opportunity for the school year 1965-66. Evidence relating teacher characteristics to student achievement is combined with data on the costs of obtaining teachers with different characteristics. This evaluation suggests that recruiting and retaining teachers with higher verbal scores is five to ten times as effective per dollar of teacher expenditure in raising achievement scores of students as the strategy of obtaining teachers with more experience. Separate estimates are made for black and for white 6th graders in schools of the metropolitan North.

COST-EFFECTIVENESS ANALYSIS AND EDUCATIONAL POLICY--PROFUSION, CONFUSION, PROMISE

Henry M. Levin*

Introduction

While the title of this paper is tripartite, I will devote only small attention to the "profusion" and "confusion" and most of my efforts to the "promise." Over the last two decades our society has experienced a revolution in decision-making processes. Among the new family of management tools, the most universally used techniques are probably those relating to cost-effectiveness analysis. Broadly speaking, these tools enable us to estimate the probable costs and benefits of alternative management strategies and subsequently to select those approaches which yield the best outcomes for any given cost.[1]

At the same time that cost-effectiveness techniques have been refined and applied, we have become increasingly aware of the failures of the large-city schools. In particular, the educational systems of the cities have failed to effectively teach or significantly motivate large numbers of disadvantaged youngsters.[2] The recent governmental

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*Assistant Professor, School of Education and Department of Economics, Stanford University. An earlier version of this paper was presented at the 34th Annual Meeting of the Operations Research Society of America, Philadelphia, November 8, 1968.

[1]A recent overview can be found in Thomas A. Goldman (ed.) Cost Effectiveness Analysis: New Approaches in Decision-Making (New York: Frederick A. Praeger, Inc., 1967).

[2]These failures have been so well recognized that they are topics of the daily press. For some insights see Christopher Jencks, "Is the Public School Obsolete?" The Public Interest (Winter 1966), pp. 18-28.

response to these failures has been to increase spending for the schools in order to compensate for disadvantages in the backgrounds of their students. Indeed, the Elementary and Secondary Education Act of 1965 alone has provided over $1 billion a year in additional school expenditures for students from low-income families.

Profusion

Given these enormous infusions of dollars, school districts, state governments, and the U.S. Office of Education have been increasingly concerned about how to get the most impact out of the additional financial support. These governments have looked increasingly to cost-effectiveness analysts for the answers, and the response has been a profuse outpouring of cost-effectiveness studies.[3] Interestingly, each of these studies has examined the relationship between total costs and a hypothetical set of outcomes without examining the particular programs on which the money was spent. That is, the process by which education is produced has been ignored, and only a gross relation between dollar expenditures and outputs has been surveyed.

Confusion

Yet the decision maker is faced with the problem of how to spend additional resources in the most effective way possible. In doing this he is handicapped by some formidable obstacles. First, there is little unanimity on what schooling output is or on how to measure a multi-dimensional array of outcomes. Second, there is almost no theory which

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[3]Some of the most extensive are: Thomas I. Ribich, Education and Poverty (Washington, D.C., The Brookings Institution, 1968). Robert Spiegelman, et al., Cost-Benefit Model to Evaluate Educational Programs, "Progress Report," Stanford Research Institute (March 1967), and "A Benefit/Cost Model to Evaluate Educational Programs," Stanford Research Institute (January 1968). Clark C. Abt, et al., "Design for an Elementary and Secondary Cost Effectiveness Model," Contract OEC 1-6-001681-1681, Report on the Mathematical Design Phase for U.S. Office of Education (February 1967). Jacob J. Kaufman, et al., "An Analysis of the Comparative Costs and Benefits of Vocational Versus Academic Education in Secondary Schools," Contract OEG-1-6-000512-0817, Preliminary Report for the U.S. Office of Education (October 1967).

describes the relations between schooling inputs, the educational process, and schooling outcomes. And third, there is even a great deal of vagueness on what should be considered as schooling inputs. For example, it has been suggested that students contribute to the education of fellow students and that teachers' attitudes may be more important than other teachers' characteristics. Finally, even student performance on standardized achievement scores is so confounded by the student's own social class, his abilities, and his general environmental milieu, that it has proven very difficult to measure school effects separately from those caused by other influences.[4]

The result of all this confusion is that additional expenditures for education have been spent in very traditional ways, most particularly on reductions in class size and the addition of remedial specialists. This very unimaginative route is taken despite the plethora of alternatives that are available: new instructional technologies, radically different curricula, and different types of teachers represent possibilities that have been scarcely considered while schools do more of what they've always done with reduced class sizes and a few additional specialists. Unfortunately, the cost-effectiveness studies undertaken thus far have done little to delineate the most effective strategies for any particular objective (e.g., raising reading scores). Indeed, one study has stated this shortcoming quite honestly: "A key part of this final analysis, which is missing completely from this study, is the analysis of how differences

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[4]The sparsity of knowledge in all of these areas is demonstrated in James S. Coleman, et al., Equality of Educational Opportunity (Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1966), Chapter III; and Samuel S. Bowles and Henry M. Levin, "The Determinants of Scholastic Achievement," The Journal of Human Resources (Winter 1968), pp. 3-24. For a discussion of the problems in doing cost-effectiveness analysis in education, see Samuel S. Bowles, "Towards an Educational Production Function," A paper presented at the Conference on Research in Income and Wealth, University of Wisconsin (November 15, 1968; and Henry M. Levin, "Cost Effectiveness Evaluation of Instructional Technology: The Problems," A paper prepared for the Commission on Instructional Technology (Washington, D.C.: November 1968).

in program inputs can affect the direct measures of achievement."[5]

Yet at the same time virtually all of the studies overwhelm the decision-maker with discussions of Markov properties, algebraic manipulations, integrals, computer algorithms, flow diagrams, mock printouts, simulation "findings" and so on. While these concepts are elementary to the analyst, they are bewildering to the man who is managing the schools. Worse yet, when he looks between the partial derivatives and sigmas, he sees no answers to his particular problems. In short, we as cost-effectiveness analysts have extolled our skills in solving the problems of the schools; we have agreed to help the decision-makers; we have taken their money; and in return we have bestowed upon them the jargon of our trade. We have not been very helpful.

Promise

This pessimistic introduction brings us to a crucial juncture. Can any cost-effectiveness analysis be done at this time that might lead to more efficient production of schooling? If the answer were an unequivocal no, we would have to CALL EXIT and return the forum to more productive discourse. In my view, however, we should continue program execution, for there is already promise of findings that should be helpful to educational decision-makers. I wish to emphasize that what follows is just a beginning, subject to qualification and subsequent modification. Nevertheless, I believe that it is a meaningful beginning.

If one were to attempt to help the school decision-maker spend his money more efficiently, where would he start? An obvious place to begin would appear to be teacher recruitment, for teachers' salaries represent about 70 percent of current operating expenditures for the elementary and secondary schools. Thus we might want to ask two questions:

(1) Which teachers' characteristics show a relation to a goal that most of us would accept for the schools, i.e.,

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[5]See Robert Spiegelman, et al. (1968), p. 54.

student performance on a standardized test of verbal achievement?

(2) What does it cost the schools to obtain teachers with different characteristics?

Given answers to these two questions, we wish to ascertain whether we can obtain teachers with more effectiveness per dollar of expenditure.

The first question might be answered if we were to estimate a production function of the form:

(1) $A = F(X,Y,Z_1, \ldots, Z_k)$

Where A is the achievement score for an individual, X represents a vector of social class and background influences which affect achievement, Y represents a vector of non-teacher characteristics for the schools, and $Z_1, \ldots, Z_k$ represents a vector of teacher attributes. Ordinarily the assumption is made that F is convex to the origin and continuous throughout its domain (and that the first order partial derivatives are positive and the second order partials are negative).

Corresponding to question (2) would be a budget constraint

(2) $B = (P_1Z_2 + P_2Z_2 + \ldots + P_kZ_k)$

which in this case would apply only to the teachers' costs, where $P_1, \ldots, P_k$ denote the prices of teacher characteristics $Z_1, \ldots, Z_k$ respectively. Let us call this a teachers' quality budget constraint, since we are assuming that teacher-student ratios are constant, and that the question before us is that of obtaining teachers of a better quality for a given teachers' budget.[6]

While we are using this example only for illustrative purposes, this approach does have the advantages of keeping the problem down to a

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[6]The elimination of class size as a parameter of achievement is based on the fact that no rigorous study has shown a consistent relation between class size and achievement within the ranges of class size under consideration. For evidence that even drastic reductions in class size and student/teacher ratios show little effect on standardized achievement scores see David J. Fox, "Expansion of the More Effective School Program," Evaluation of New York City Title I Educational Projects 1966-67 (New York: Center for Urban Education, 1967), pp. 32-44.

manageable--but still meaningful--size.

Assume that we wish to maximize (1) subject to constraint (2). The solution to this problem would require obtaining each type of teachers' quality Z_i until its additional contribution to achievement ($\partial A/\partial Z_i$) relative to its price (P_i) were equal for all Z_i ($i = 1, \ldots, k$). That is:[7]

$$(3) \quad \frac{\partial A/\partial Z_1}{P_1} = \frac{\partial A/\partial Z_2}{P_2} = \ldots = \frac{\partial A/\partial Z_k}{P_k}$$

What if the school decision-maker has no knowledge of production relation (1) or the relative prices (P_i) in (2)? This is certainly likely to be the case in the present instance where the knowledge gap is so great. Yet, assume that the decision-maker does indeed wish to maximize (1). Then, as cost-effectiveness analysts, we would like to give him information as to which teacher characteristics represent "best buys" in improving achievement scores within the confines of a limited budget.

We do possess information supporting the view that for any given salary, schools can probably recruit teachers who are more effective than those whom they are presently obtaining. For example, Table 1 shows two production equations for Negro verbal achievement at Grade 12. The specific data were taken from the U.S. Office of Education's Survey of Educational Opportunity, and these particular equations represent those derived from original specifications with over 20 variables.[8] Both teachers' salaries and an incomplete--but logical--measure of teacher quality, teachers'

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[7]The derivation of this solution is assumed to be familiar to the reader. Others may refer to Paul A. Samuelson, Foundations of Economic Analysis (Cambridge, Massachusetts, Harvard University Press, 1961). For a formal proof see H. Hancock, The Theory of Maxima and Minima (New York: Dover Press, 1960).

[8]Regression coefficients that were not significantly different from zero at the 5 per cent level were eliminated from the specification. For further discussion of these results see Samuel S. Bowles and Henry M. Levin, "Equality of Educational Opportunity: More on Multicolinearity and the Effectiveness of Schools," The Journal of Human Resources (Summer 1968), pp. 393-400.

verbal scores, show strong relations to student achievement. Yet, the teacher's verbal score seems to represent a "better fit" in explaining variance in student achievement. This suggests that schools are not properly considering the price-productivity relation for the different characteristics of teachers obtainable at different salary levels.[9]

TABLE 1

Regression Equations for Negro Verbal Achievement at Grade 12.

X_1 = Negro student's verbal score
X_2 = Reading material in home
X_3 = Siblings (positive equals few)
X_4 = Parents' education
X_5 = Science-lab facilities
X_6 = Teacher salary (in thousands of dollars)
X_7 = Teacher verbal score

(1) $X_1 = 33.40 + 1.99X_2 + 1.86X_3 + 2.49X_4 + 0.062X_5 + 1.78X_6$
(2.66) (4.34) (4.49) (3.18) (5.95)

$R^2 = .1506$

X'X = .68 = Measure of collinearity

(2) $X_1 = 19.49 + 2.09X_2 + 1.81X_3 + 2.42X_4 + 0.050X_5 + 1.24X_7$
(2.82) (4.25) (4.38) (2.58) (7.14)

$R^2 = .1633$

X'X = .68 = Measure of collinearity

Note: (1) The t-values appear in parentheses; (2) definitions of the variables appear in James S. Coleman, et al., Equality of Educational Opportunity, U.S. Department of Health, Education, and Welfare (Washington, D.C.: 1966), Volume II, pp. iii-vii.

[9] An alternative explanation is that price-level differences among schools in a geographically dispersed sample create measurement errors in salaries, whereas no such problem arises with teachers' verbal scores.

Production Estimates

What follows are the results from admittedly early representations of (1) and (2) which I believe yield insights into the teacher recruitment problem. Eric Hanushek has estimated educational production functions for black and for white 6th graders in metropolitan schools.[10] Using standardized achievement scores as measures of output and other data on inputs from the Survey of Equal Opportunity data, Hanushek estimated relations similar to (1) for whites in 471 elementary schools and for blacks in 242 elementary schools in the metropolitan North. Thus the analyses were cross-sectional single equation estimates for 1965-66 done separately for black and for white students. While Hanushek properly specified these functions using social class and other variables as arguments, we will discuss only the estimated relationships between teacher characteristics and student verbal score.

TABLE 2

Means and Standard Deviations for
Samples of Negro and White 6th Graders

	Negro		White	
	Mean	St. Dev.	Mean	St. Dev.
Student Verbal Score	26.68	4.20	35.70	4.54
Teacher Verbal Score	23.98	1.80	24.77	1.43
Teacher Experience (Years)	11.29	4.00	11.88	4.56

Source: Eric Hanushek, op. cit., p. 39 and p. 75.

[10] "The Education of Negroes and Whites," unpublished doctoral dissertation (Department of Economics, Massachusetts Institute of Technology, 1968).

TABLE 3

Output in Student Verbal Score for Each Additional Unit of Teacher Verbal Score and Experience

	Additional Points of Student Verbal Score	
	Negro	White
Each Additional Unit of Teacher Verbal Score	.175	.179
Each Additional Year of Teacher Experience	.108	.060

Source: Estimated from results on p. 37 and p. 73 in Eric Hanushek, op. cit.

In general, Hanushek found two teacher characteristics that were consistently related to the verbal scores of 6th graders. These two traits were the number of years of teacher experience and teacher's verbal score. The means and standard deviations for these variables are shown in Table 2 and the estimated payoffs to each characteristic are displayed in Table 3.[11]

Thus for each additional point of teacher verbal score the Negro students showed an increment of .175 points and the white students an increment of .179 points in student verbal score. For each additional year of teacher experience, the test scores of Negro students were about .108 points higher and the test scores of white students were about .060 points higher.

[11]These estimated payoffs represent approximate slope coefficients for linear relationships between student's verbal score and the specific teacher characteristics, extracted from an equation in which other relevant explanatory valuables were also included in the relationships. Teacher's degree level and other traits showed no statistically significant association with student achievement.

Teacher Costs

The relative prices for teacher characteristics are taken from my estimates of earnings functions for teachers.[12] In this work I estimated the relationship between teachers' salaries and teachers' characteristics. The estimates were derived for four metropolitan regions considered as labor markets, and the data were derived from the same source as that used by Hanushek.

Table 4 shows the annual dollar return to teachers for specific characteristics within an eastern metropolitan region. While this result represents a linear function for an aggregate sample of teachers, results are available for non-linear forms of the equation and by sex and race of teacher analyzed separately. For illustrative purposes, however, this equation will suffice.

Among this large sample of almost 3,000 teachers, about $24.00 of annual salary was associated with each additional point of teacher's verbal score; males were receiving about $400 more than females; and each additional year of college training was worth almost $400 to a teacher. Teachers with non-academic majors were receiving about $160 more than were their counterparts who majored in elementary education or academic subjects; graduates of teacher colleges were receiving less than graduates of other institutions. For each additional year of teaching experience, teachers were receiving about $79, and there were also higher returns to each successive certification level and to dissatisfaction with the racial composition of one's students ("discrepancy on proportion white").

What is of particular interest to us is that the approximate annual cost to the schools of obtaining a teacher with an additional year of experience was about $79 and that of obtaining a teacher with an additional point on the verbal scale was about $24, ceteris paribus. Applying these estimates to the results on Table 3, we can estimate the approximate costs of raising student test scores with two strategies: recruiting and

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[12] Henry M. Levin, "Recruiting Teachers for Large-City Schools," (Washington, D.C.: The Brookings Institution, forthcoming).

TABLE 4

Estimation of Earnings Functions
for Eastmet Teachers

Teacher Characteristics	Slope Coefficient	t Statistic
Verbal Score	$ 23.98	5.6
Female	-398.59	10.1
Years of schooling	396.04	17.8
Miscellaneous major	159.73	3.5
Graduate of teachers' college	-125.73	3.0
Years of experience	78.91	36.0
Certification level	564.09	23.1
Discrepancy on Proportion White	18.27	2.3
Mean Salary	7,084.56	
Standard Deviation	1,679.76	
$\bar{R}_2$	.80	
R	.65	
Sample Size	2921	

retaining teachers with more experience, and recruiting and retaining teachers with higher verbal scores.

Some Findings

Applying these returns we derive Table 5, which shows the relative costs of improving student performances under alternative recruitment strategies.[13] It is important to emphasize the relative costs of each

[13] These costs were obtained by applying the teacher's experience and verbal score salary coefficients in Table 4 to the production coefficients in Table 3. It was assumed that the additional effort would have to be maintained for the first five years of schooling in order to obtain the sixth grade results shown in Table 3. Therefore, the present values in Table 5 represent additional expenditures for the previous five years compounded at a 5 percent rate of interest and divided by an average class size of 30 in order to obtain a per-student figure.

strategy rather than the absolute ones.[14] In terms of relative costs, for a given test score gain for Negroes, it appears that obtaining teachers with higher verbal scores is about 1/5 as costly as obtaining more teacher experience; and the teachers' verbal score route is ten times as efficient as teacher's experience per dollar of expenditure for increasing the verbal scores of white students. The obvious policy implication is that school districts are obtaining too much experience as against verbal proficiency. Accordingly, the schools should try to increase the recruitment and retention of verbally able teachers while paying somewhat less attention to experience. How much tradeoff should be made is not evident given our linear results.[15]

TABLE 5

Relative Costs of Increasing Student Verbal Achievement

	Approximate Cost for Increasing a Student's Verbal Score by One Point	
Strategy	Negro	White
Teacher's Verbal Score	$ 26	$ 26
Teacher Experience	$128	$253

Another interesting observation is that teacher experience appears to be twice as effective per dollar of expenditure for Negro students as it does for white ones. Giving equal weights to point gains for whites and Negroes, the schools might wish to assign their more experienced teachers to the schools attended by Negro students for higher total yields. That is, the more experienced teachers should be redistributed to the Negro schools.

[14]The additional costs are probably biased downwards because the original salary data from which costs are estimated did not include fringe benefits.

[15]That is, our production estimates do not satisfy the conditions of the second order partial derivative set out for equation (1) above.

These findings are not the final answer by any means. They are meant to be illustrative rather than definitive. There are grounds for expecting specification biases on both the production and cost sides. Yet, it would take enormous biases--all in the same direction--to offset our finding that it appears far more efficient to improve student achievement by raising teachers' verbal score than by increasing teacher experience.

Further efforts in expanding this analysis and subjecting the present findings to additional scrutiny are being carried out by Hanushek of the U.S. Air Force Academy, Stephan Michelson and Samuel Bowles of Harvard, and the present author. We shall shortly see whether the promise that seems to be evident in this approach is justified.